Chemical Action that is Stimulated by Alternating Currents.

By S. G. Brown.

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The following experiments were carried out in the year 1905. Taking a simple voltaic cell, consisting of an anode and cathode of zinc and carbon, and an electrolyte of dilute sulphuric acid, it was found that polarisation, which takes place when the cell is joined to a local circuit of low resistance, could be diminished or completely abolished, by passing through the cell an alternating current of suitable value. Fig. 1 illustrates the arrangement of the cell, D, joined up to deliver current through the ampèremeter, B; under

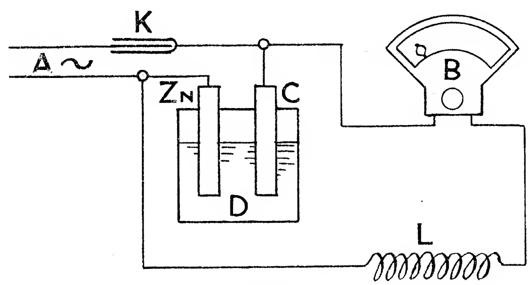


Fig. 1.

these conditions the cell is very quickly polarised, and the continuous current falls to a very low figure.

On the other hand, if a suitable strength of alternating current of, say, 100 periods per second is sent through the cell from the leads A, the cell D will be completely depolarised and will give its full current delivery. L is a self-induction and K a capacity to prevent the alternating and continuous currents from flowing in each other's circuit, the only part of the circuit common to both being through the cell.

If the alternating current has a frequency of, say, 12,000 periods per second, and we place a carbon transmitter in its circuit, on speaking into the transmitter the speech will be very correctly reproduced, by variations correspondingly produced in the value of the continuous current from D, and the voice will be heard correctly in a telephone included in the circuit with B. This shows that the rise and fall in the value of the continuous current immediately follows that of the mean strength of the alternating current.

The polarising effect in the cell is caused, as is well known, by the coating

of gas bubbles on the cathode; when the alternating current is switched on not only is the production of gas increased, due to the increased output of current from the cell, but the gas bubbles appear to shoot away at right angles to the surface of the cathode.

Another arrangement of the cell, as shown in fig. 2, was tested under similar electrical conditions, and in this case the cathode had a large surface exposed, and the zinc anode was just touching the liquid so as to only expose a small surface to the action of the electrolyte. Under these conditions, and keeping the cell free from vibration, something similar to polarisation sets in and the current delivery, which is at first large, soon falls to a very low value. The action of this cell was the same if the carbon was exposed to the electrolyte directly or placed within a porous cell in contact with strong nitric acid, proving that the falling off of current was not due to gaseous polarisation but to the restrained chemical action on the zinc anode caused by the depletion of the active properties of the electrolyte in immediate contact with the anode. The effect of the alternating current was the same as before, and the cell under the stimulating action would greatly increase its current delivery, proving that in some manner the alternating current increases the solvent action of the electrolyte on the anode.

I have indicated diagrammatically the final state of the cell in fig. 2, before the alternating current is applied. A shows the depleted area around the

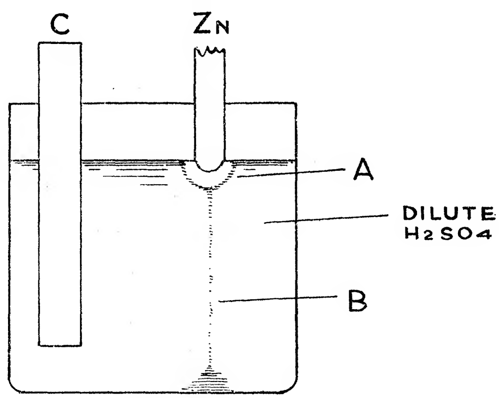


Fig. 2.

zinc anode; the sulphuric acid ions have to be projected or diffused through this area before they can unite with the zinc to form zinc sulphate. This sulphate, although colourless, can be observed, by the refracting action on light, to be falling in a thin steady stream B to the bottom of the cell. The alternating current appears to increase the velocity of the ions in some manner and enable them to traverse the depleted area and dissolve

more zinc. This is seen by the increase in the zinc sulphate stream and the larger current supplied by the cell.

By making the surface of the anode in contact with the electrolyte small in area, the action of the alternating current will be concentrated and the ions will be correspondingly increased in chemical activity. In one case the anode was constructed of a fine platinum wire dipping about one-tenth of an inch into the dilute sulphuric acid and an external battery of two volts applied. When the alternating current was superimposed the platinum started to oxidise, and in a short time the whole of the wire in contact with the liquid was turned into a black powder. The same thing happened with gold, the wire turned into a yellow insoluble powder. With the filament of a carbon lamp as anode the carbon was completely dissolved or turned into gas; and, in fact, no conducting material could be found that would resist the combined action of the two currents when applied in this concentrated manner.

These experiments were carried out with alternating currents at a frequency of 12,000 periods per second, as it was thought that the stimulating effects were much greater at high frequencies, but no tests were made to prove this point.

Many forms of cells and batteries were tried, and it was found that in every case where the anode was constructed of a soluble metal, and was arranged to project as little as possible into the electrolyte, the alternating current would stimulate the chemical action and force the cell, or cells, to deliver a greater output of current. Also, several metals that were insoluble in the liquid without the alternating current became soluble when this current was applied.

Another action of alternating currents was illustrated by the following experiment. In fig. 3, the circuit of the 2-volt battery was interrupted by the

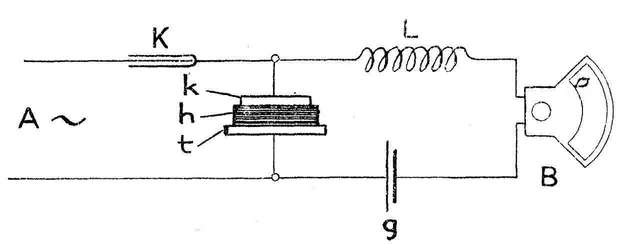


Fig. 3.

cake of compressed oxide of lead placed between the bright lead plate, *k*, and a platinum anode, *t*. The current flowed from the platinum to the lead so as to make the lead plate the cathode. In this direction the cathode did not

oxidise, and a maximum current passed through the arrangement. When a high-frequency current was applied an increase in chemical action took place, which oxidised the lead plate superficially and produced a back E.M.F., and thus reduced the continuous current through the cell. Here we have a case of stimulated chemical action without the use of a fluid dielectric. Other metals were tried in place of the lead, and in every case it was found that the continuous current fell when the alternating was applied, but only three metals were found that would allow the continuous current to spring back to its original high value as soon as the alternating currents were discontinued. These three metals were bismuth, lead, and thallium, and they required 3, 2, and $1\frac{1}{2}$ volts in their local batteries respectively to give the best results. The function of the alternating current is to stimulate the chemical changes, it may be to produce oxidation as in the foregoing experiments, or in other cases it may be to reduce the oxide, although no direct test was made to prove this supposition.

I think that these experiments explain the action of the Branley filings coherer—a device in which the group of granules act normally as an insulator, but become conductive when high-frequency currents such as Hertz waves pass through them. Iron or nickel filings are insulated from each other by a thin film of oxide, but the coherer has a small capacity, with the oxide as dielectric, and the waves are thus allowed to pass. The rapid alternating currents act upon the oxide dielectric and, by stimulating chemical action, reduce the oxide at the points of contact to a metallic or conducting form and allow a continuous current to flow. When the tube is shaken the oxide again intervenes and another application of the alternating current is required to produce conduction.

The actions that I have here indicated seem to me to be much like that which takes place in many catalytic processes: a chemical action taking place between two substances only when a third substance is present, although the third substance does not seem to suffer any chemical change itself. It may be possible, therefore, that the combined action of the alternating and continuous currents will be of value in electro-chemical processes.

It was at one time hoped that by applying a small alternating current to a cell it would be possible to unlock a much greater continuous current in return, or in other words that the cell would act as a relay; but from many tests it would seem that this cannot take place, and in no case was the continuous current output of energy greater or as great as the ingoing alternating energy of the stimulated cell.

Fig. 4 shows the connections as arranged to test numerically the effects of the high frequency currents in the cell or cells, D. The high frequency was

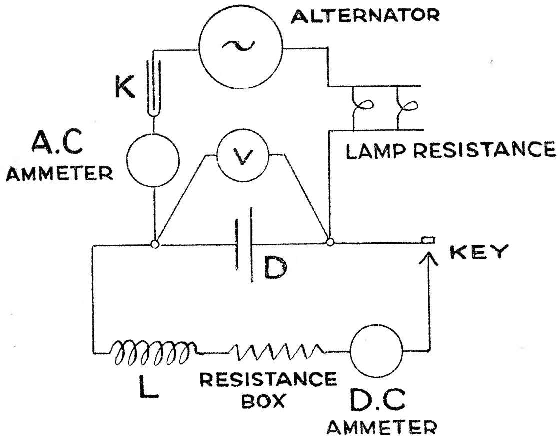


FIG. 4.

run throughout to give 12,000 oscillations per second. The other essential features of the arrangement are :—

K, a capacity of 1 microfarad.

AC, a twisted strip ampèremeter with shunts.

DC, a moving coil milliampèremeter.

V, an electrostatic voltmeter charged inductively.

L, a large magnetic shunt of about 10 henries and 15 ohms resistance.

The alternating current was controlled by incandescent lamps and the continuous current by a resistance box.

The battery of cells, D, had a zinc-carbon element with an unamalgamated zinc rod 5/16 inch diameter with a pointed tip. The carbon rod had a diameter of 3/8 inch, 2 inches being exposed to the liquid, which was dilute sulphuric acid of sp. gr. 1·200.

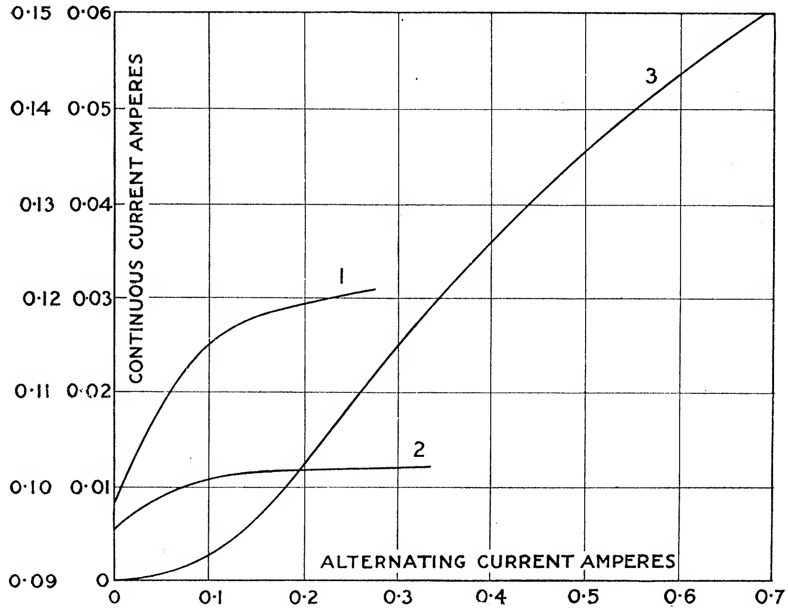
The results of the experiments are given in figs. 5 and 6.

Curve 1, fig. 5, represents the relation between the alternating and continuous current when the zinc just touched the liquid. Ten cells in series were used, and the continuous current was short-circuited through the milliampèremeter.

Curve 2 represents the results with the same arrangement, except that a resistance of 150 ohms was inserted in the milliampèremeter circuit.

Curve 3 refers to the case where two sets of five cells in parallel were connected in series. The zero of the vertical scale is here displaced as indicated by the outer figures.

Experiments were also made with a single cell. The results are given in fig. 6, the different curves refer to differences in the arrangement as follows :—


0·15 0·06
0·14 0·05
0·13 0·04
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CONTINUOUS CURRENT AMPERES
1
2
3
ALTERNATING CURRENT AMPERES
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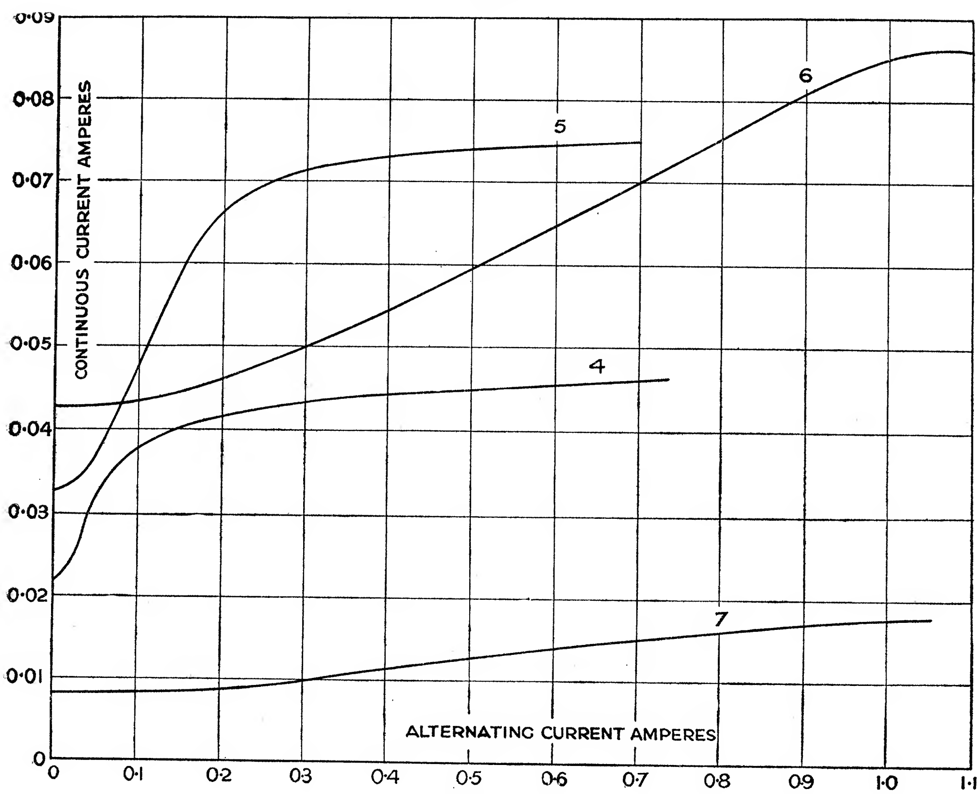
0·2
0·3
0·4
0·5
0·6
0·7

Fig. 5.


0·09
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0·01
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CONTINUOUS CURRENT AMPERES
4
5
6
7
ALTERNATING CURRENT AMPERES
0
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
1·1

Fig. 6.

Curve 4. The current passed through one cell in which 2 inches of carbon was exposed, but only the tip of the zinc rod touched the liquid. The values given for the continuous current are for short circuit through the ampère-meter in this and the following.

Curve 5. 2 inches of carbon rod and $\frac{1}{4}$ inch of zinc rod exposed.

Curve 6. 2 inches of carbon rod and 2 inches of zinc rod exposed.

Curve 7. Carbon tip only and 2 inches of zinc rod exposed.

The results may be summarised as follows:—

(1) The effect of a given alternating current was much larger when all the cells were in series than when two sets, of five cells each, in parallel were used. The ratio of the increase was approximately, with the cells in series, change in alternating current : change in continuous current :: 5 : 1 with 10 cells in series.

With two sets of five parallel cells, change in alternating current : change in continuous current :: 12 : 1.

(2) While the surface of the carbon exposed to the electrolyte only affects the results in so far as it increases the resistance of the cell, the current density at the zinc electrode alters the change in the continuous current greatly.

On the Effect of the Gangetic Alluvium on the Plumb-line in Northern India.

By R. D. Oldham, F.R.S.

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For some years past, the Annual Reports of the Survey of India, and of the Indian Government Board of Scientific Advice, have contained references to the remarkable character of the deflections of the plumb-line at stations near the southern edge of the Himalayas. These facts, and the explanation which has been adopted by Colonel S. G. Burrard, Surveyor-General for India, have recently been brought into prominence by the publication of a memoir* on "The Origin of the Himalayas," certain parts of which are in contradiction with the conclusions, regarding the structure of the range, that had been drawn from geological observations.

Briefly stated, the geodetic facts are as follows. Along the southern edge of the Himalayas very high northerly deflections, amounting to about 40″ of

* 'Survey of India,' Professional Paper No. 12, Calcutta, 1912.